Attachment G
Hazard Analysis and Critical Control Point Technical Memo

Hazen *Memorandum*

June 2, 2017

To: Lauren Zuravnsky, PE

From: Dwayne Amos, PE
Andrew Newbold, PE, BCEE
Troy Walker, MIE(Aust)
Meric Selbes, PhD
Aaron Duke, PE, BCEE

Re: SWIFT Research Center Hazard Analysis and Critical Control Point Memorandum

The purpose of this document is to provide a summary of the Hazard Analysis and Critical Control Point (HACCP) review of the Sustainable Water Initiative for Tomorrow Research Center (SWIFTRC) advanced water treatment and groundwater recharge process for the Hampton Roads Sanitation District (HRSD) Sustainable Water Phase 3 – Demonstration Facility Project. This memorandum will also provide a basis for future updates of the HACCP water quality risk assessment as the intent is to keep it as a "living document" that can be modified as new treatment techniques, SWIFT Water quality goals, or risks are identified during the program.

1. Background

The Hazard Analysis Critical Control Point (HACCP) methodology has been adopted internationally by numerous countries [1] to manage microbial and chemical contaminants in water treatment systems, including recycled water systems. The HACCP system is a logical, scientific methodology designed to identify, evaluate, and control hazards, which are significant for human health protection. The purpose of a HACCP system is to put in place controls or actions that will prevent or detect and correct deviations in treatment processes at the earliest possible opportunity. HACCP focuses on monitoring and maintaining treatment barriers, rather than relying solely on end-of-pipe sampling and testing. This provides a dual advantage of ensuring that high quality water is produced and minimizing end-of-pipe monitoring and associated costs and risks.

HACCP, or just the use of critical control points (CCPs), has been applied to a number of water recycling (including water reuse) projects to demonstrate the management of microbiological and chemical risks through a multiple barrier approach. A CCP is a point in the treatment train (i.e., a unit treatment process) that is designed specifically to reduce, prevent, or eliminate a human health hazard and for which controls exist to ensure the proper performance of that process. The projects using this approach include the Orange County Water District's Groundwater Recharge System and the Western Corridor Recycled Water Scheme in Australia, among others. The risk-based approach to water treatment has been widely adopted to illustrate to regulators that risks associated with recycled water have been fully considered and

[1] Notably, the World Health Organization (WHO) relies upon the HACCP process as outlined in their Guidelines for Drinking Water Quality, 4th Edition which has been adopted by numerous countries around the world for both water and potable reuse projects. Examples of such countries include Canada, Australia, New Zealand, France, and Namibia. The U.S. Environmental Protection Agency (EPA) also provides an excellent summary of the HACCP framework, including international examples, and how it could be applied in the US to manage risks in drinking water distribution systems. (http://www.epa.gov/safewater/disinfection/tcr/pdfs/issuepaper_tcr_haccp-strategies.pdf)

addressed. This methodology provides flexibility in treatment options, which facilitates the adoption of alternative approaches for treatment.

2. HACCP Process

The HACCP process is categorized into seven principles that can be used to guide the process of developing critical control points and operational response strategies for water recycling systems. The principles help challenge and refine assumptions behind process selection, analytical sampling (analyte list and monitoring frequency), process monitoring, and corrective actions, all of which ultimately support full-scale design, implementation, and operation. The seven principles are listed below:

Principle 1: Conduct a hazard analysis (water quality risk assessment)

Principle 2: Determine the CCPs

Principle 3: Establish critical limits (assess barrier performance)

Principle 4: Establish a system to monitor the control of a CCP

Principle 5: Establish the corrective action to be taken when CCP monitoring is out of range

Principle 6: Establish procedures for verification to confirm that the CCP system is working effectively

Principle 7: Establish documentation concerning all procedures and records appropriate to these principles and their application

The purpose of the memo is to communicate the results of the hazard analysis (Principle 1), confirm the CCPs previously discussed with HRSD (Principle 2), and confirm the critical limits and establish monitoring systems (Principles 3 and 4). Principles 5, 6, and 7 will be included with subsequent revisions to this memo, after CCPs and critical limits have been confirmed.

Holistically considering the design, operation, and overall asset management of the water infrastructure to ensure robust and reliable performance prior to the development and execution of the program is critical. Up-front evaluations can provide significant costs savings in terms of outside sample analysis and selection of process monitors, as well as reducing the number of repeat experiments/measurements, by ensuring that properly focused questions and goals are developed. Therefore, the focus of this memorandum is to provide a summary of the HACCP assessment for the SWIFTRC treatment process, addressing the first four HACCP principles as described in Reuse-13-03 (Walker, Stanford et al., 2016)[2]. The remaining principles will be addressed during final phases of construction but prior to startup and commissioning.

[2] Walker, T., B. D. Stanford, S. Khan, C. Robillot, R. Valerdi, S. A. Snyder, S. Dwivedi and J. Vickers (2016). Critical Control Point Assessment to Quantify Robustness and Reliability of Multiple Treatment Barriers of a DPR Scheme (WRRF-13-03). WateReuse Research Foundation, Alexandria, VA**:** 318 pages.

2.1 Principles 1 & 2: Hazard Analysis and Critical Control Point Assessment

2.1.1 Plant Layout Confirmation

Prior to the hazard analysis and critical control point assessment, the process layouts for HRSD Nansemond Treatment Plant (NP) and the SWIFTRC were confirmed, including a review of any return flows and chemical inputs into the treatment scheme.

A hazard analysis and critical control point workshop was conducted on November 30, 2016 at the York River Treatment Plant. HRSD project stakeholders, consisting of technical, project, and management leadership staff, and Hazen and Sawyer stepped through each process train to make sure the process flow diagrams to be used in the risk assessment were accurate and included all of the available chemical inputs and monitoring points. A follow up workshop was conducted on May 15, 2017, after the treatment process design was nearly final, to revisit and confirm the CCPs and establish critical limits. The current process train is shown in **Figure 2-1**. This process flow diagram shows both NP and the SWIFTRC processes on one diagram even though they are separate facilities.

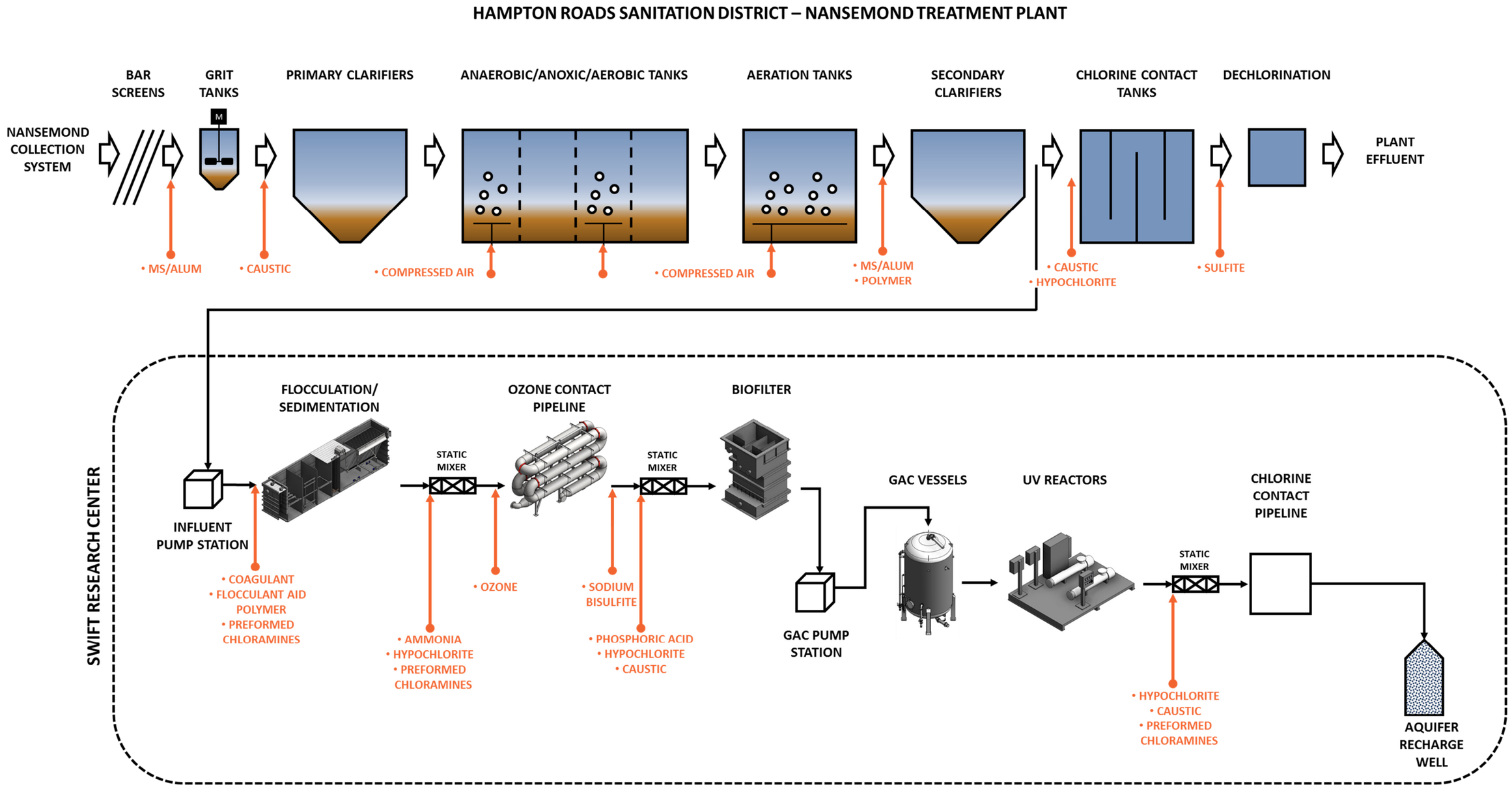

Figure 2-1: HRSD Nansemond Treatment Plant Processes with SWIFTRC

2.1.2 Water Quality Risk Assessment

A water quality risk assessment[3] was conducted with input from the HRSD staff (operations, engineering, planning) together with Hazen staff. Water quality targets focused on U.S. Environmental Protection Agency (EPA) primary drinking water regulations and included some proposed California drinking water regulations. Virginia Department of Environmental Quality (DEQ) and Virginia Department of Health (VDH) regulations were also considered if they were more stringent than the federal regulations. Secondary standards were also included in this analysis for specific individual constituents.

The risk assessment process involved two separate components. The first component consisted of identifying source water hazards and assessing the suitability of the wastewater treatment process and the SWIFTRC treatment process to reduce the inherent risk to an acceptable level. As such, the following steps were followed:

- List and categorize all health hazards with drinking water benchmarks or maximum contaminant levels
- Assess the potential severity and likelihood of those health hazards without any treatment
- Review the treatment barriers available to protect against those risks

The list of hazards used in the initial risk assessment was established based on EPA, Virginia DEQ, VDH, and California drinking water quality guidelines/targets as well as some utility-specified contaminants. Through these sources, the team covered a wide range of biological contaminants, inorganics and metals, radionuclides, volatile and synthetic organic compounds (SOCs), disinfection byproducts (DBPs) and disinfectants, as well as other various chemical inputs.

The second component of the risk assessment consisted of evaluating the impact associated with hazardous events and how such risks would be mitigated by implementing CCP monitors and other quality control measures. As such, the following steps were followed:

- Consider hazardous events that could occur at the treatment facility
- Assess the water quality impact associated with those events and their likelihood
- Establish additional control/mitigation measures for hazardous events that might create unacceptable risk

From previous research (WateReuse 13-03 and the World Health Organization [WHO]), a predetermined set of definitions for likelihood and consequences was developed and is illustrated in **Table 2-1** and **Table 2-2**.

[3] The term "risk assessment" used here is consistent with the World Health Organization's Water Safety Plan Manual (http://apps.who.int/iris/bitstream/10665/75141/1/9789241562638_eng.pdf) and their Guidelines for Drinking Water Quality (http://apps.who.int/iris/bitstream/10665/44584/1/9789241548151_eng.pdf), and applies specifically to the HACCP methodology being used throughout this evaluation.

Table 2-1: Likelihood Descriptions

Likelihood	Description
Almost Certain	Is expected to occur with a probability of multiple occurrences within a year
Likely	Will probably occur within a 1 to 5 year period
Possible	Might occur or should be expected to occur within a 5 to 10 year period
Unlikely	Could occur within 20 years or in unusual circumstances
Rare	May occur only in exceptional circumstances; May occur once in 100 years

Table 2-2: Consequence Descriptions

Consequence	Description	Detailed Example
Catastrophic	Major impact for a large population	Widespread acute health impact expected, resulting in hospitalization and/or decreased life expectancy
Major	Major impact for a small population	Potential acute health impact affecting a limited number of the community
Moderate	Minor impact for a large population	Repeated breach of a chronic health parameter, long term/lifetime exposure required or potential widespread aesthetic impact
Minor	Minor impact for a small population	Elevated levels of a chronic health parameter no health impact expected or potential local aesthetic impact
Insignificant	Insignificant impact or not detectable	No expected health impacts or an isolated exceedance of an aesthetic parameter

Also, from previous work (WateReuse-13-03) and based on WHO guidelines, a risk matrix was developed to systematically categorize the impact and define risk levels that would be considered significant and/or unacceptable. Low to moderate risks have been deemed acceptable and high or very high risks have been defined as requiring additional treatment or mitigation efforts to reduce that risk level. The various risk levels are show in **Table 2-3**.

Table 2-3: Likelihood and Consequence Matrix

Likelihood	Consequence				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Catastrophic	Low (E1)	Moderate (E2)	High (E3)	Very High (E4)	Very High (E5)
Major	Low (D1)	Moderate (D2)	High (D3)	Very High (D4)	Very High (D5)
Moderate	Low (C1)	Moderate (C2)	High C3)	Very High (C4)	Very High (C5)
Minor	Low (B1)	Low (B2)	Moderate (B3)	High (B4)	Very High (B5)
Insignificant	Low (A1)	Low (A2)	Low (A3)	High (A4)	High (A5)

Finally, specific water quality/human health risks were categorized relative to the certainty around the known occurrence data and were used in conjunction with the initial risk assessment. These certainty definitions are the product of scientific evidence and data available for the specific contaminant and/or treatment process. The ratings are described in **Table 2-4**.

Table 2-4: Uncertainty Descriptions

Degree of Uncertainty	Description
Certain	There is 5 years of continuous monitoring data which has been trended and assessed; with at least daily monitoring; or the processes involved are thoroughly understood
Confident	There is 5 years of continuous monitoring data, which has been collated and assessed, with at least weekly monitoring or for the duration of seasonal events; or there is a good understanding of the processes involved
Reliable	There is at least a year of continuous monitoring data available which has been assessed; or there is a reasonable understanding of the processes involved
Estimate	There is limited monitoring data available; or there is a limited understanding of the processes involved
Uncertain	There is limited or no monitoring data available; or the processes are not well understood

The inherent risk was established by assuming that raw wastewater would be consumed directly without any treatment. While this is an unrealistic scenario, it provides a highly conservative and comprehensive approach to addressing the range of potential risks, while demonstrating the risk mitigating effects of both the wastewater treatment process and the SWIFTRC treatment process before aquifer recharge.

Appendix A provides a summary of the identified hazards, a target concentration of those hazards (based on the lower of EPA or Virginia DEQ, or VDH regulations, or in some cases, California-specific goals that may be on the horizon for the EPA), and where data were available; the measured concentration in the NP influent and/or effluent. This table should be updated as new source water characterization data

are collected during the course of the demonstration period. Additionally, the master Risk Assessment spreadsheet (example table shown in **Appendix A**) will calculate and color-code the ratio of maximum observed concentration in the source water (NP influent) to the water quality target. For ratios less than 0.5, little-to-no additional treatment should be needed to manage that contaminant. That said, a single measurement in time is not sufficient to characterize the risk as "present" or "absent", thus longer-term monitoring to characterize trends (if any) or to identify high-concentration events for acute risk contaminants is recommended. In the absence of long-term monitoring data or a high degree of confidence that the contaminant will not be present in the system (as determined by characterizing the industries present in the collection system and inherent treatment barriers at NP), it should be assumed that barriers will be required to manage that contaminant. **Appendix B** provides a summary of the reported industrial chemicals used in the NP collection system. However, once a long-term source water quality assessment is conducted, many chronic contaminants can have their occurrence data moved to "insignificant" resulting in "low" risks in the register.

Some of the observations from the hazard assessment include:

- Biological contaminants were assessed as presenting a very high risk based on their prevalence in raw wastewater, estimated concentration, and public health impact if not effectively treated.
- Inorganics, with the exception of nitrate, have a likelihood level of "possible" in the NP secondary effluent; however, based on the concentrations identified in raw wastewater historical data, the risk level could range anywhere from low to high.
- Among the inorganics, nitrate was considered to present a very high risk in secondary effluent based on its prevalence, estimated concentration and public health impact if not effectively treated.
- Volatile organic compounds (VOCs) have a likelihood level of "possible"; however, based on the concentrations identified in the raw wastewater historical data, the risk level could range anywhere from low to high.
- SOCs were also expected to have a likelihood level of "possible" and would range in risk levels from low to high depending on the concentration and the impacts from industrial sources and agricultural runoff.
- The formation of DBPs is possible in the treatment process (though the process is designed to specifically prevent their formation). As such, trihalomethanes, haloacetic acids, bromate, and nitrogenous DBPs could pose a moderate risk depending on concentration as well as the specific process parameters.

2.1.3 Determination of Critical Control Points

The HACCP process was used to define the critical control points at the SWIFTRC. The CCP methodology is shown in the decision tree on the following page (WateReuse-13-13). During the assessment, the team stepped through each process to determine whether or not the process was a CCP. The decision tree that was used to identify CCPs is shown in **Figure 2-2**.

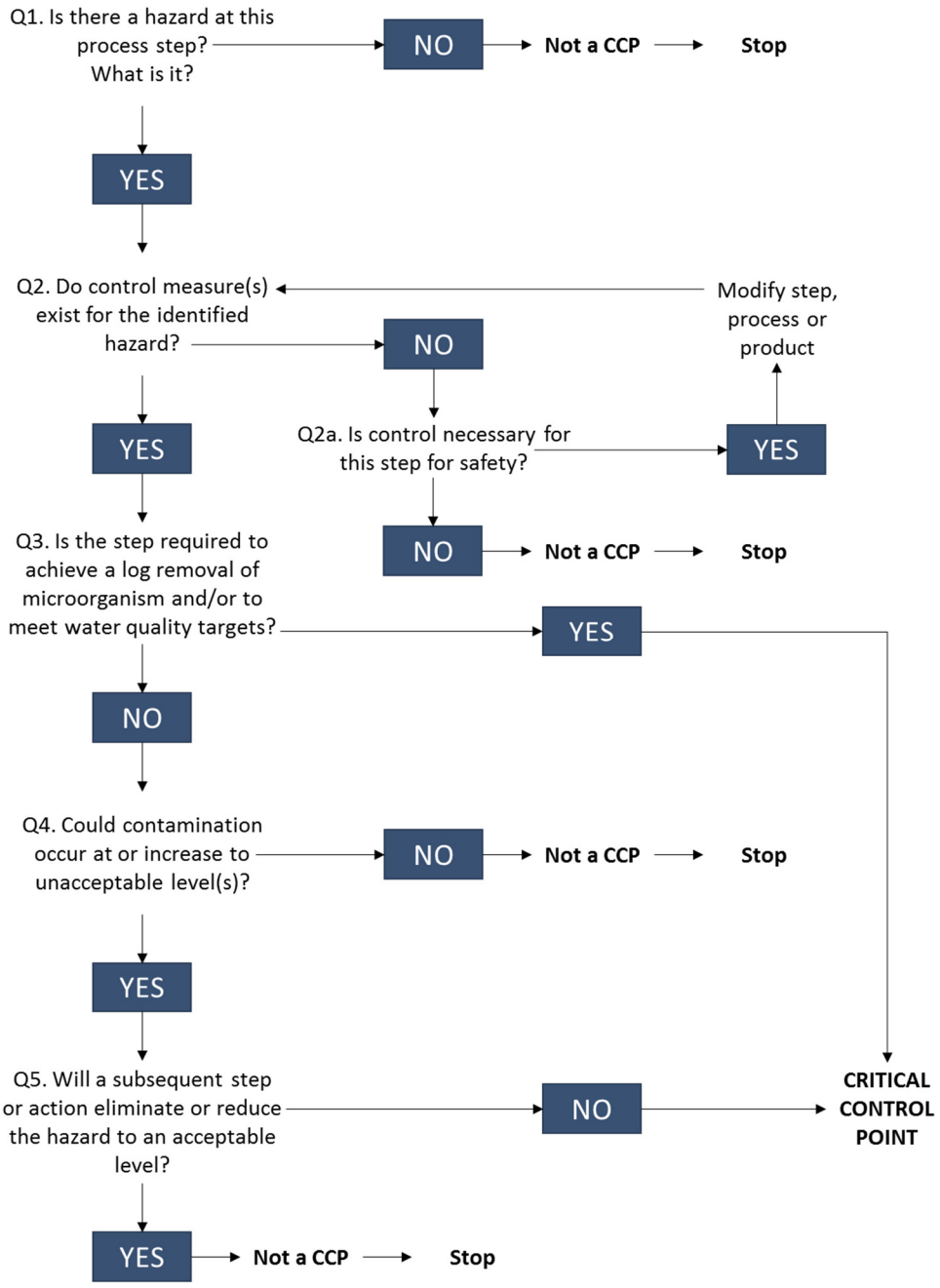

Figure 2-2: Decision Tree for Determining CCPs

This methodology provides a logical sequence of questions to ensure rigor in the selection of the CCPs. **Table 2-5** provides a summary of the final CCPs for the SWIFTRC. The team's response to each one of the questions has been detailed in **Table 2-5** and briefly provides the rationale for the decisions made.

Table 2-5: Documentation of CCPs Identified (Non-CCPs are not shown)

	CCPs	Q1. Is there a hazard at this process?	Q2. Do control measures exist for the identified hazard?	Q3. Is the step required to achieve disinfection and/or to meet water quality targets?	Q4. Could contamination occur or increase to unacceptable levels?	Q5. Will a subsequent step reduce the hazard to an acceptable level?	Monitoring Parameters
SWIFTRC	IPS	Yes (Nitrate, Nitrite, Pathogens, DBP Precursors)	Yes	Yes	Yes	N/A	Conductivity Total Inorganic Nitrogen Turbidity
	Chlorine + Ammonia	Yes (DBPs)	Yes	Yes	Yes	No	Chloramine Feed Total Chlorine
	Ozone	Yes (Chemicals and Pathogens)	Yes	Yes	Yes	N/A	Ozone Feed Ozone Contactor LRV - Virus
	BAF	Yes (Pathogens)	Yes	Yes	Yes	N/A	Individual Filter Effluent Turbidity Combined Filter Effluent Turbidity
	GAC	Yes (SOCs/VOCs)	Yes	Yes	Yes	N/A	TOC
	UV	Yes (Pathogens)	Yes	Yes	Yes	N/A	UV Dose
	Chemical Disinfection[1]	Yes (Pathogens)	Yes	Yes	Yes	N/A	Free Chlorine CT

[1] Chemical Disinfection only a CCP if free chlorination used for virus inactivation
BAF = biologically active filtration
CT = contact time
GAC = granular activated carbon
IPS = influent pump station
LRV = log removal value
N/A = not applicable
TOC = total organic carbon
UV = ultraviolet

For each of the collected CCPs, we also identified monitoring parameters to ensure the CCP performance. For demonstration, these CCP monitors should be used to correlate observed removals of contaminants through the analytical sampling plan. These data could later be used to inform the development of operational limits ("alarm" and "action") and the appropriate operational response procedures. **Table 2-6** illustrates each of the CCPs selected, the hazards they control, and their respective monitoring parameters.

Table 2-6: CCPs, Hazards Controlled, and Monitoring Parameters

CCPs	Hazards Controlled	Monitoring Parameters
IPS	Nitrate, Nitrite, Pathogens, DBP Precursors	Conductivity Total Inorganic Nitrogen Turbidity
Chlorine + Ammonia	DBPs	Chloramine Feed Total Chlorine
Ozone	Chemicals and Pathogens	Ozone Feed Ozone Contactor LRV - Virus
BAF	Pathogens	IFE Turbidity CFE Turbidity
GAC	SOCs/VOCs	TOC
UV	Pathogens	UV Dose
Chemical Disinfection[1]	Pathogens	Free Chlorine CT

[1] Chemical Disinfection only a CCP if free chlorination used for virus inactivation
IFE = individual filter effluent
CFE = combined filter effluent

2.2 Principles 3 & 4: Establish Critical Limits (Assess Barrier Performance) and Establish Monitoring Systems

Beyond the selection of the CCPs and the initial risk assessment, the HACCP team assessed the capability of the wastewater treatment process and the SWIFTRC to remove contaminants based on extensive literature review. **Table 2-7** provides a summary of the wastewater treatment process and SWIFTRC process and their respective treatment capabilities for each potential contaminant hazard. An initial quantification of removal was selected based on current experimental and published data, however this table is meant to be a living document that should be edited with future data and expert opinions on the various treatment techniques. Note that the SWIFTRC will have the ability to provide additional disinfection using free chlorine prior to aquifer recharge, however this treatment barrier is currently not included in the Hazard Control Analysis since free chlorination is not anticipated to be used as a part of the aquifer recharge treatment process.

The list of contaminants presented in **Table 2-7** is based on typical wastewater characteristics and not based on site specific NP data. For all contaminants where site specific data was available, the concentrations were below detection limits, as shown in **Appendix A**. Given the limited site-specific data set, the fact that some compounds were below detection limits did not factor into the analysis. As such, there are contaminants included on the list that may not be present in the NP wastewater.

The following symbols are used throughout the tables to indicate the removal of a contaminant by each treatment process. In some cases (e.g., copper), removal may occur in some steps while a control mechanism (e.g., orthophosphate addition) may occur in others. The color coding is the same, though in the cases where control is applied the term “removal” would be replaced with “control”.

○	No removal expected
◑	Ancillary removal but no control mechanism
◕	Some removal with operational controls in place
●	Good removal with operational controls in place
	No data available

(Note, with DBPs control may be prevention instead of removal)

Table 2-7: Hazard Control by Treatment Process

Hazard	Inherent Risk (Raw WW)	Nansemond Plant & Influent Pump Station	Floc/Sed	Floc/Sed-BAF	Ammonia and Chlorine	Ozone	Ozone-BAF	GAC	UV	Overall Treatment	SWIFT Water Risk (Post-SWIFTRC)
Pathogens											
Cryptosporidium	Very High (E5)	◑	◑	●	○	◕	●	◑	●	●	Low (A1)
Giardia lamblia	Very High (E5)	◑	◑	●	○	●	●	◑	●	●	Low (A1)
Total Coliforms (incl. fecal coliform and *E. Coli*)	Very High (E5)	◑	◑	●	○	●	●	◑	●	●	Low (A1)
Viruses (enteric)	Very High (E5)	◑	◑	◕	○	●	◕	◑	●	●	Low (A1)
Inorganics and metals											
Aluminum	Moderate (B3)	◑	◑	○	○	○	○	○	○	○	Low (B2)
Antimony	Moderate (B3)	◑	◑	○	○	○	○	○	○	○	Low (B2)
Arsenic	Moderate (B3)	◑	◑	○	○	○	○	○	○	●	Low (B2)
Asbestos	Low (B1)	◑	◑	○	○	○	○	○	○	○	Low (B1)
Barium	Low (B2)	◑	◑	○	○	○	○	○	○	○	Low (B2)
Beryllium	Moderate (B3)	◑	◑	○	○	○	○	○	○	○	Low (B2)
Cadmium	Moderate (B3)	◑	◑	○	○	○	○	○	○	○	Low (B2)
Chloride	Low (B2)	○	○	○	○	○	○	○	○	○	Low (B2)
Chromium	Moderate (B3)	◑	◑	○	○	○	○	○	○	○	Low (B2)
Copper	Low (B2)	◑	◑	○	○	○	○	○	○	○	Low (B2)
Cyanide	Moderate (B3)	◑	○	○	○	○	○	○	○	○	Low (B2)
Fluoride	Low (B2)	○	○	○	○	○	○	○	○	○	Low (B2)
Iron	Low (B2)	◑	◑	○	○	○	◕	○	○	●	Low (B1)
Lead	Moderate (B3)	◑	◑	○	○	○	○	○	○	○	Low (B2)
Manganese	Moderate (B3)	◑	◑	○	○	○	◕	○	○	●	Low (B1)
Mercury	Moderate (B3)	◑	◑	○	○	◑	○	○	○	◑	Low (B2)
Nickel	Moderate (B3)	◑	◑	○	○	◑	○	○	○	◑	Low (B2)
Nitrate (as N)	Very High (D4)	●	○	○	○	○	○	○	○	●	Moderate (C2)

Hazard	Inherent Risk (Raw WW)	Nansemond Plant & Influent Pump Station	Floc/Sed	Floc/Sed-BAF	Ammonia and Chlorine	Ozone	Ozone-BAF	GAC	UV	Overall Treatment	SWIFT Water Risk (Post-SWIFTRC)
Nitrite (as N)	High (D3)	●	○	○	○	●	◕	○	○	●	Low (B2)
Silver	Low (B2)	◑	◑	○	○	○	○	○	○	◑	Low (B2)
Sulfate	Low (B2)	◑	○	○	○	○	○	○	○	○	Low (B2)
Selenium	Moderate (B3)	◑	◑	○	○	○	○	○	○	◑	Low (B2)
Thallium	Low (B2)	◑	◑	○	○	○	○	○	○	◑	Low (B2)
Zinc	Low (B2)	◑	◑	○	○	○	○	○	○	◑	Low (B2)
Radionuclides											
Uranium	Moderate (B3)	○	◑	○	○	○	○	○	○	◑	Low (B2)
Combined Radium - 226+228	Moderate (B3)	○	◑	○	○	○	○	○	○	◑	Low (B2)
Gross Alpha particle activity (excluding radon & uranium)	Moderate (B3)	○	○	○	○	○	○	○	○	○	Low (B2)
Gross Beta particle activity	Moderate (B3)	○	○	○	○	○	○	○	○	○	Low (B2)
Strontium -90	Moderate (B3)	○	◑	○	○	○	○	○	○	◑	Low (B2)
Tritium	Moderate (B3)	○	○	○	○	○	○	○	○	○	Low (A2)
VOCs											
Aniline	Moderate (C2)	◕	○	○	○	◑	○	◕	○	◕	Low (B1)
Benzene	Moderate (C2)	◕	○	○	○	◑	○	◕	○	◕	Low (B1)
Benzyl Chloride	High (C3)	◕	○	○	○	◑	○	◕	○	◕	Low (B2)
Carbon Tetrachloride	High (C3)	◕	○	○	○	◑	○	◕	○	◕	Low (B2)
o-Dichlorobenzene	High (C3)	◕	○	○	○	◑	○	●	○	●	Low (B1)
p-Dichlorobenzene	High (C3)	◕	○	○	○	◑	○	●	○	●	Low (B1)
1,2-Dichloroethane	High (C3)	◕	○	○	○	◑	○	◕	○	◕	Low (B1)
Dichloromethane	High (C3)	◕	○	○	○	◑	○	◑	○	◕	Low (B2)
1,2-Dichloropropane	Moderate (C2)	◕	○	○	○	◑	○	◕	○	◕	Low (B1)
1,3-Butadiene	Low (C1)	◕	○	○	○	◑	○	◑	○	◕	Low (B1)
1,1-Dichloroethane	Moderate (C2)	◕	○	○	○	◑	○	◑	○	◕	Low (B2)
Nitrobenzene	Moderate (C2)	◕	○	○	○	◑	○	●	○	●	Low (B2)

Hazard	Inherent Risk (Raw WW)	Nansemond Plant & Influent Pump Station	Floc/Sed	Floc/Sed-BAF	Ammonia and Chlorine	Ozone	Ozone-BAF	GAC	UV	Overall Treatment	SWIFT Water Risk (Post-SWIFTRC)
Tetrachloroethylene	High (C3)	◕	○	○	○	◑	○	●	○	●	Low (B2)
Oxirane Methyl	Low (C1)	◕	○	○	○	◑	○	◑	○	◕	Low (B1)
1,1,1-Trichloroethylene	Low (C1)	◕	○	○	○	◑	○	◑	○	◕	Low (B1)
1,2,3-Trichloropropane	Moderate (C2)	◕	○	○	○	◑	○	◑	○	◕	Low (B2)
Urethane	Moderate (C2)	◕	○	○	○	◑	○	◑	○	◕	Low (B2)
Trichloroethylene	Moderate (C2)	◕	○	○	○	◑	○	◑	○	◕	Low (B2)
Vinyl chloride	High (C3)	◕	○	○	○	◑	○	◑	○	◕	Low (B2)
SOCs											
Acrylamide	High (C3)	◑	○	○	○	○	○	◕	○	◕	Moderate (C2)
Alachlor	High (C3)	○	○	○	○	◑	○	●	○	●	Low (B1)
Atrazine	High (C3)	○	○	○	○	◑	○	●	○	●	Low (B1)
Benzo(a) Pyrene	Moderate (C2)	○	○	○	○	◑	○	●	○	●	Low (B1)
Carbofuran	High (C3)	○	○	○	○	◑	○	●	○	●	Low (B2)
Chlordane	Moderate (C2)	○	○	○	○	◑	○	●	○	●	Low (B1)
Dalapon	Moderate (C2)	○	○	○	○	◑	○	◕	○	◕	Low (B2)
Dibromochloropropane	Moderate (C2)	○	○	○	○	◑	○	◕	○	◕	Low (B2)
Di(2-ethylhexyl)adipate	Moderate (C2)	○	○	○	○	◑	○	◕	○	◕	Low (B2)
Di(2-ethylhexyl)phthalate	Moderate (C2)	○	○	○	○	◑	○	◕	○	◕	Low (B2)
1,4-Dioxane	Moderate (C2)	○	○	○	○	◑	○	◕	○	◕	Low (B2)
2,4-D	Moderate (C2)	○	○	○	○	◑	○	●	○	●	Low (B2)
Dinoseb	Moderate (C2)	○	○	○	○	◑	○	◕	○	◕	Low (B2)
Diquat	High (C3)	○	○	○	○	◑	○	◕	○	◕	Low (B2)
Endothall	Moderate (C2)	○	○	○	○	◑	○	◕	○	◕	Low (B2)
Endrin	Moderate (C2)	○	○	○	○	◑	○	●	○	●	Low (B2)
Epichlorohydrin	High (C3)	◑	○	○	○	◑	○	◕	○	◕	Moderate (C2)

Hazard	Inherent Risk (Raw WW)	Nansemond Plant & Influent Pump Station	Floc/Sed	Floc/Sed-BAF	Ammonia and Chlorine	Ozone	Ozone-BAF	GAC	UV	Overall Treatment	SWIFT Water Risk (Post-SWIFTRC)
Ethylene Dibromide	Moderate (C2)	○	○	○	○	◑	○	◕	○	◕	Low (B2)
Glyphosate	Moderate (C2)	○	○	○	○	◑	○	◕	○	◕	Low (B2)
Heptachlor	High (C3)	○	○	○	○	◑	○	●	○	●	Low (B1)
Heptachlor Epoxide	High (C3)	○	○	○	○	◑	○	●	○	●	Low (B1)
Hexachlorobenzene	High (C3)	○	○	○	○	◑	○	●	○	●	Low (B1)
Hexachlorocyclopentadiene	Moderate (C2)	○	○	○	○	◑	○	●	○	●	Low (B1)
Lindane	High (C3)	○	○	○	○	◑	○	●	○	●	Low (B1)
Methoxychlor	Moderate (C2)	○	○	○	○	◑	○	●	○	●	Low (B1)
Oxamyl	Moderate (C2)	○	○	○	○	◑	○	◕	○	◕	Low (B1)
Pentachlorophenol	Moderate (C2)	○	○	○	○	◑	○	◕	○	◕	Low (B1)
Picloram	Moderate (C2)	○	○	○	○	◑	○	●	○	●	Low (B1)
Perfluorocarbons	Moderate (C2)	○	○	○	○	◑	○	●	○	●	Low (B1)
Polychlorinated Biphenyls	High (C3)	○	○	○	○	◑	○	●	○	●	Low (B1)
Simazine	High (C3)	○	○	○	○	◑	○	●	○	●	Low (B1)
Styrene	High (C3)	○	○	○	○	◑	○	◕	○	◕	Low (B2)
Toxaphene	High (C3)	○	○	○	○	◑	○	◕	○	◕	Low (B2)
2,3,7,8-TCDD (Dioxin)	Moderate (C2)	○	○	○	○	◑	○	●	○	●	Low (B1)
2,4,5-TP (Silvex)	Moderate (C2)	○	○	○	○	◑	○	◕	○	◕	Low (B1)
DBPs and Disinfectants											
Bromate	Moderate (C2)	○	○	○	◕	○	○	○	○	◕	Low (B2)
Chlorate	Moderate (D2)	○	○	○	◕	○	○	○	○	◕	Low (B2)
Haloacetic acids (five) Precursors	High(E3)	○	◕	◕	○	◑	◕	●	○	●	Low (C1)
Haloacetic acids (five)	High(E3)	○	○	○	○	○	●	●	○	●	Low (B2)
NDMA Precursors	High(E3)	◑	◑	◕	◕	◕	◕	◕	○	●	Low (B1)
NDMA	High(E3)	○	○	○	○	◑	◕	◕	◕	●	Low (B2)
Perchlorate	Moderate (C2)	○	○	○	◕	○	○	○	○	◕	Low (B2)

Hazard	Inherent Risk (Raw WW)	Nansemond Plant & Influent Pump Station	Floc/Sed	Floc/Sed-BAF	Ammonia and Chlorine	Ozone	Ozone-BAF	GAC	UV	Overall Treatment	SWIFT Water Risk (Post-SWIFTRC)
Total Trihalomethanes Precursors	High(E3)	○	◕	◕	○	◑	◕	●	○	●	Low (C1)
Total Trihalomethanes	High(E3)	◕	○	○	○	○	◑	●	○	●	Low (B2)

Notes:

NDMA = n-nitrosodimethylamine

TP = (trichlorophenoxy)propionic acid

2.2.1 Barrier Assessment

The SWIFTRC treatment process LRVs for Viruses, *Cryptosporidium*, and *Giardia lamblia* are shown in **Table 2-8**. The combined treatment trains could achieve greater than 13-log removal of *Cryptosporidium* (the California-based target is 10-log), 12.5-log removal of *Giardia* (the California-based target is 10-log) and 12-log removal of viruses (the California-based target is 12-log). Such treatment provides well beyond the minimum level of treatment needed to ensure public health protection from pathogenic microorganisms.

Table 2-8: SWIFTRC Recharge Water Pathogen LRV

Parameter	Floc/Sed & BAF[1]	Ozone[2]	BAF & GAC	UV[3]	Cl2	SAT	Total
Enteric Viruses	2	3 (TBD)	0	4	0-4	6	12-19
Cryptosporidium	4	0	0	6 (4 Allowed)	0	6	14-16
Giardia lamblia	2.5	1.5 (TBD)	0	6 (4 Allowed)	0	6	12.5-16

1. Coag/Sed/BAF provides 2-log virus removal, 4 LRV for Cryptosporidium for a well-operated plant per the LT2ESWTR, and 2.5 LRV for Giardia.
2. Prior to confirming pathogen removal through soil aquifer treatment (SAT), ozone will be operated to achieve 3 LRV for viruses and 1.5 LRV for Giardia.
3. LRV in accordance with the UV Disinfection Guidance Manual for the Final LT2ESWTR.

SAT = soil aquifer treatment
TBD = to be determined

Based on the initial assessment of water quality data, treatment barriers, and industries present, all SWIFT Water risks were ranked at "Low (A1) with the exception of nitrate, nitrite, epichlorohydrin, and acrylamide which were all ranked at "Moderate (C2)" risks. For nitrate and nitrite, monitoring at the SWIFTRC IPS and diversion of water with unacceptable levels of these compounds is the primary mechanism for managing those contaminants. Better characterization of NP treatment performance for the

continuous control of nitrate will allow the risk assessment team to adjust the "likelihood" of events occurring and better define what additional controls (if any) will need to be in place to manage nitrate. Epichlorohydrin and acrylamide are both managed via coagulant dosing strategies (i.e., not over-dosing polymer solutions) and because there is a possibility that overdose conditions could occur, the risk matrix assigns the risk level as "moderate". The master Risk Assessment matrix should be updated when additional sources of risk or treatment barrier performance information (e.g. SAT) becomes available.

2.2.2 CCPs

The process flow diagram with the CCPs highlighted and associated numbered monitoring points has been provided with specific information about the monitoring locations for various CCPs (**Figure 2-3**). The descriptions for each monitoring site are explained in **Table 2-9**.

Table 2-9: CCPs with CCP Monitoring Points

CCP	CCP Monitor No.	Description
IPS	**1**	Monitor turbidity, total inorganic nitrogen, and conductivity
Chlorine + Ammonia	**2**	Monitor total chlorine residual and preformed chloramine feed equipment to assess chloramination process
Ozone	**3**	Monitor ozone feed equipment to assess ozonation process
	4	Monitor ozone contactor LRV to assess ozonation process
BAF	**5**	Monitor IFE and CFE (combined filter effluent) turbidity to assess BAF performance
GAC	**6**	Monitor effluent TOC to assess GAC performance
UV	**7**	Monitor UV dose to assess UV performance
Chemical Disinfection[1]	**8**	Monitor free chlorine CT to assess chemical disinfection performance

[1] Chemical Disinfection only a CCP if free chlorination used for virus inactivation

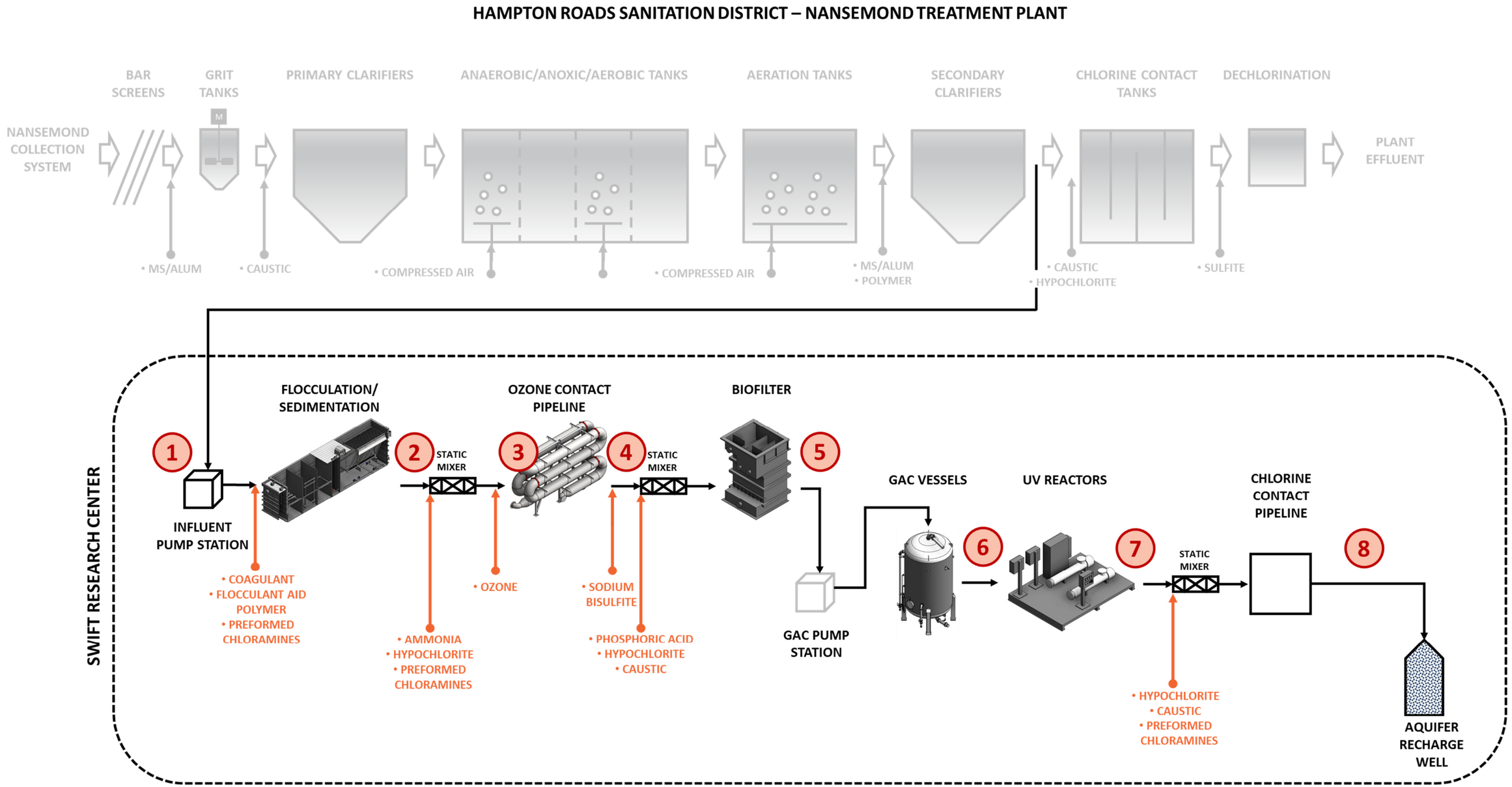

Figure 2-3: Process Flow Diagram with CCP Monitoring Points for the SWIFTRC

The CCP monitor alarm and action values associated with the monitoring points are presented in **Table** 2-10.

Table 2-10: Critical Control Point Monitoring Parameters

Parameter	Alarm Value	Action Value	Unit	Action
Influent Pump Station Conductivity	1,000	1,500	µS/cm	Divert settled water to Drain Pump Station or stop influent pumps
Influent Pump Station Total Inorganic Nitrogen	5.0	6.0	mg/L	Divert settled water to Drain Pump Station or stop influent pumps
Influent Pump Station Turbidity	15	20	NTU	Divert settled water to Drain Pump Station or stop influent pumps
Preformed Chloramine Failure on Injection	N/A	Failure	mg/L	Divert SWIFT Water
Total Chlorine Post Injection Upstream of Ozone	2.0	1.0	mg/L	Divert SWIFT Water
Ozone Feed	N/A	Failure	N/A	Divert SWIFT Water AND Open Biofilter Backwash Waste Valve[1]
Ozone Contactor Calculated LRV – Virus	<120% LRV Goal	<100% LRV Goal	%	Divert SWIFT Water AND Open Biofilter Backwash Waste Valve[1]
Biofilter Individual Effluent Turbidity	0.1	0.15	NTU	Place filter in standby at Alarm Value. Divert filter effluent at Action Value
Biofilter Combined Filter Effluent Turbidity	0.1	0.15	NTU	Divert SWIFT Water
GAC Effluent TOC, instantaneous online analyzer	4.0	6.0	mg/L	Divert SWIFT Water
UV Reactor Dose	<120% of Dose Setpoint	<105% of Dose Setpoint	%	Divert SWIFT Water
Free Chlorine CT[2]	<120% of CT Target	<105% of CT Target	%	Divert SWIFT Water

[1] Opening the Biofilter Backwash Waste Valve will avoid the operation of the biofilters with un-ozonated water. The reason for doing this is to minimize the accumulation of pathogens and pathogen indicators in the biofilters.

[2] Free Chlorine CT only a CCP Monitor if free chlorination used for virus inactivation

µS/cm = microsiemen per centimeter
mg/L = milligram(s) per liter
NTU = nephelometric turbidity unit

2.2.3 Revisiting the Risk Assessment

The Risk Assessment document (both as this Memorandum as well as the master Risk Assessment Spreadsheet) is meant to be a living document that is updated as new information becomes available regarding the presence of specific contaminants and the measured removal of those contaminants across the barriers. As such, this memorandum and the spreadsheet should be revisited during the demonstration period to ascertain whether the initial assumptions and assertions are still valid and to determine if any revisions need to be made for the SWIFT program. Likewise, it is recommended that the HACCP team use this document and site-specific unit process operating experience as a means to develop targeted operational response procedures so the operations team can get experience in applying the procedures (and modifying as necessary). Both of these activities (revisiting the risk assessment and developing and testing the response procedures) will benefit future full-scale operation.

2.3 Principles 5: Critical Control Point Operational Strategies and Response Procedures

After the list of CCPs has been confirmed, this section will provide a review of each of the identified CCPs and provide an overview of corrective action to be taken when CCP monitoring is out of range. Responses will be outlined for both alarm (warning) and action (failure) values for each process.

Appendix A: Source Water Risk Characterization Matrix (empty cells indicate no available data)

Hazard	Target (lower of EPA & VDH)	Unit	Ratio Max/Target Influent	Ratio Max/Target Effluent	Impact	Source	Notes	Inherent Risk (based on drinking untreated NP influent directly at 2 liters per day)		
								Consequence at Raw Water Concentration	Likelihood	Risk
Biological										
Cryptosporidium	TT				Acute Health	Domestic waste - human and animal faecal matter Contamination of storage reservoirs		Catastrophic	Almost Certain	Very High (E5)
Giardia lamblia	TT				Acute Health	Domestic waste - human and animal faecal matter Contamination of storage reservoirs		Catastrophic	Almost Certain	Very High (E5)
Total Coliforms (incl. fecal coliform and E. Coli)	less than 5% samples positive per month				Acute Health	Domestic waste - human and animal faecal matter Contamination of storage reservoirs		Catastrophic	Almost Certain	Very High (E5)
Viruses (enteric)	TT				Acute Health	Domestic waste - human and animal faecal matter Contamination of storage reservoirs		Catastrophic	Almost Certain	Very High (E5)

Hazard	Target (lower of EPA & VDH)	Unit	Ratio Max/Target Influent	Ratio Max/Target Effluent	Impact	Source	Notes	Inherent Risk (based on drinking untreated NP influent directly at 2 liters per day)		
								Consequence at Raw Water Concentration	Likelihood	Risk
Inorganics and metals										
Aluminum	0.05 to 0.2	mg/L			Chronic Health	Lime stabilization		Moderate	Unlikely	Moderate (B3)
Antimony	0.006	mg/L	0	0	Chronic Health	Trade waste, Domestic waste, Illegal discharge		Moderate	Unlikely	Moderate (B3)
Arsenic	0.01	mg/L	0	0	Chronic Health	Trade waste, Domestic waste, Illegal discharge		Moderate	Unlikely	Moderate (B3)
Asbestos	7	million fibers /L			Chronic Health	Trade waste, Domestic waste, Illegal discharge		Insignificant	Unlikely	Low (B1)
Barium	2	mg/L			Chronic Health	Trade waste, Domestic waste, Illegal discharge		Minor	Unlikely	Low (B2)
Beryllium	0.004	mg/L	0	0	Chronic Health	Trade waste, Domestic waste, Illegal discharge		Moderate	Unlikely	Moderate (B3)
Cadmium	0.005	mg/L	0	0	Chronic Health	Trade waste, Domestic waste, Illegal discharge		Moderate	Unlikely	Moderate (B3)
Chloride	250	mg/L			Chronic Health	Trade waste, Domestic waste, Illegal discharge		Minor	Unlikely	Low (B2)
Chromium	0.1	mg/L	0	0	Chronic Health	Trade waste, Domestic waste, Illegal discharge		Moderate	Unlikely	Moderate (B3)
Copper	1	mg/L	0	0	Chronic Health	Trade waste, Domestic waste, Illegal discharge		Minor	Unlikely	Low (B2)
Cyanide	0.2	mg/L	0	0	Chronic Health	Trade waste, Domestic waste, Illegal discharge		Moderate	Unlikely	Moderate (B3)

Hazard	Target (lower of EPA & VDH)	Unit	Ratio Max/Target Influent	Ratio Max/Target Effluent	Impact	Source	Notes	Inherent Risk (based on drinking untreated NP influent directly at 2 liters per day)		
								Consequence at Raw Water Concentration	Likelihood	Risk
Fluoride	0.7	mg/L			Chronic Health	Trade waste, Domestic waste, Illegal discharge		Minor	Unlikely	Low (B2)
Iron	0.3	mg/L			Chronic Health	Trade waste, Domestic waste, Illegal discharge, Coagulation		Minor	Unlikely	Low (B2)
Lead	0.015	mg/L	0	0	Chronic Health	Trade waste, Domestic waste, Illegal discharge		Moderate	Unlikely	Moderate (B3)
Manganese	0.05	mg/L			Chronic Health	Trade waste, Domestic waste, Illegal discharge		Moderate	Unlikely	Moderate (B3)
Mercury	0.002	mg/L	0	0	Chronic Health	Trade waste, Domestic waste, Illegal discharge		Moderate	Unlikely	Moderate (B3)
Nickel	0.1	mg/L	0	0	Chronic Health	Trade waste, Domestic waste, Illegal discharge		Moderate	Unlikely	Moderate (B3)
Nitrate (as N)	10	mg/L			Acute--Infants	Trade waste, Domestic waste, Illegal discharge		Major	Likely	Very High (D4)
Nitrite (as N)	1	mg/L			Acute--Infants	Trade waste, Domestic waste, Illegal discharge		Moderate	Likely	High (D3)
Silver	0.1	mg/L	0	0	Chronic Health	Trade waste, Domestic waste, Illegal discharge		Minor	Unlikely	Low (B2)
Sulfate	250	mg/L			Chronic Health	Trade waste, Domestic waste, Illegal discharge Also by SBS quenching		Minor	Unlikely	Low (B2)
Selenium	0.05	mg/L	0	0	Chronic Health	Trade waste, Domestic waste, Illegal discharge		Moderate	Unlikely	Moderate (B3)
Thallium	0.002	mg/L	0	0	Chronic Health	Trade waste, Domestic waste, Illegal discharge		Minor	Unlikely	Low (B2)
Zinc	5	mg/L	0	0	Chronic Health	Trade waste, Domestic waste, Illegal discharge		Minor	Unlikely	Low (B2)

Hazard	Target (lower of EPA & VDH)	Unit	Ratio Max/Target Influent	Ratio Max/Target Effluent	Impact	Source	Notes	Inherent Risk (based on drinking untreated NP influent directly at 2 liters per day)		
								Consequence at Raw Water Concentration	Likelihood	Risk
Radionuclides										
Uranium	30	µg/L			Chronic Health	Domestic waste (radiopharmaceuticals, diffuse load) - Environmental contribution		Moderate	Unlikely	Moderate (B3)
Combined Radium - 226+228	5	pCi/L			Chronic Health			Moderate	Unlikely	Moderate (B3)
Gross Alpha particle activity (excluding radon & uranium)	15	pCi/L			Chronic Health			Moderate	Unlikely	Moderate (B3)
Gross Beta particle activity	4	millirems/year			Chronic Health			Moderate	Unlikely	Moderate (B3)
Strontium -90	8	pCi/L			Chronic Health		Not Regulated	Moderate	Unlikely	Moderate (B3)
Tritium	20,000	pCi/L			Chronic Health		Not Regulated	Moderate	Unlikely	Moderate (B3)

Hazard	Target (lower of EPA & VDH)	Unit	Ratio Max/Target Influent	Ratio Max/Target Effluent	Impact	Source	Notes	Inherent Risk (based on drinking untreated NP influent directly at 2 liters per day)		
								Consequence at Raw Water Concentration	Likelihood	Risk
VOCs										
Aniline		mg/L	0	0	Chronic Health	Trade waste, Domestic waste, Illegal discharge		Minor	Possible	Moderate (C2)
Benzene	0.005	mg/L	0	0	Chronic Health			Minor	Possible	Moderate (C2)
Benzyl Chloride		mg/L	0	0	Chronic Health			Moderate	Possible	High (C3)
Carbon Tetrachloride	0.005	mg/L	0	0	Chronic Health			Moderate	Possible	High (C3)
o-Dichlorobenzene	0.6	mg/L						Moderate	Possible	High (C3)
p-Dichlorobenzene	0.075	mg/L						Moderate	Possible	High (C3)
1,2-Dichloroethane	0.005	mg/L	0	0	Chronic Health			Moderate	Possible	High (C3)
Dichloromethane	0.005	mg/L			Chronic Health			Moderate	Possible	High (C3)
1,2-Dichloropropane	0.005	mg/L	0	0	Chronic Health			Minor	Possible	Moderate (C2)

Hazard	Target (lower of EPA & VDH)	Unit	Ratio Max/Target Influent	Ratio Max/Target Effluent	Impact	Source	Notes	Inherent Risk (based on drinking untreated NP influent directly at 2 liters per day)		
								Consequence at Raw Water Concentration	Likelihood	Risk
1,3-Butadiene		mg/L	0	0	Chronic Health			Insignificant	Possible	Low (C1)
1,1-Dichloroethane		mg/L			Chronic Health			Minor	Possible	Moderate (C2)
Nitrobenzene		mg/L			Chronic Health			Minor	Possible	Moderate (C2)
Tetrachloroethylene	0.005	mg/L	0	0	Chronic Health			Moderate	Possible	High (C3)
Oxirane Methyl		mg/L	0	0	Chronic Health			Insignificant	Possible	Low (C1)
1,1,1-Trichloroethylene	0.005	mg/L						Insignificant	Possible	Low (C1)
1,2,3-Trichloropropane		mg/L			Chronic Health			Minor	Possible	Moderate (C2)
Urethane		mg/L			Chronic Health			Minor	Possible	Moderate (C2)
Trichloroethylene	0.005	mg/L	0	0	Chronic Health			Minor	Possible	Moderate (C2)
Vinyl chloride	0.002	mg/L	0	0	Chronic Health			Moderate	Possible	High (C3)

Hazard	Target (lower of EPA & VDH)	Unit	Ratio Max/Target Influent	Ratio Max/Target Effluent	Impact	Source	Notes	Inherent Risk (based on drinking untreated NP influent directly at 2 liters per day)		
								Consequence at Raw Water Concentration	Likelihood	Risk
SOCs										
Acrylamide	TT	mg/L			Chronic Health	Trade waste, Domestic waste, Illegal discharge		Moderate	Possible	High (C3)
Alachlor	0.002	mg/L			Chronic Health	Illegal dicharges and run-off/ infiltration		Moderate	Possible	High (C3)
Atrazine	0.003	mg/L			Chronic Health	Illegal dicharges and run-off/ infiltration		Moderate	Possible	High (C3)
Benzo(a) Pyrene	0.0002	mg/L	0	0	Chronic Health	Trade waste, Domestic waste, Illegal discharge		Minor	Possible	Moderate (C2)
Carbofuran	0.04	mg/L			Chronic Health	Illegal dicharges and run-off/ infiltration		Moderate	Possible	High (C3)
Chlordane	0.002	mg/L	0	0	Chronic Health	Illegal dicharges and run-off/ infiltration		Minor	Possible	Moderate (C2)
Dalapon	0.2	mg/L			Chronic Health	Illegal dicharges and run-off/ infiltration		Minor	Possible	Moderate (C2)
Dibromochloropropane	0.0002	mg/L			Chronic Health	Illegal dicharges and run-off/ infiltration		Minor	Possible	Moderate (C2)
Di(2-ethylhexyl)adipate	0.4	mg/L			Chronic Health	Trade waste, Domestic waste, Illegal discharge		Minor	Possible	Moderate (C2)
Di(2-ethylhexyl)phthalate	0.006	mg/L			Chronic Health	Trade waste, Domestic waste, Illegal discharge		Minor	Possible	Moderate (C2)
1,4-Dioxane								Minor	Possible	Moderate (C2)

Hazard	Target (lower of EPA & VDH)	Unit	Ratio Max/Target Influent	Ratio Max/Target Effluent	Impact	Source	Notes	Inherent Risk (based on drinking untreated NP influent directly at 2 liters per day)		
								Consequence at Raw Water Concentration	Likelihood	Risk
2,4-D	0.07	mg/L			Chronic Health	Illegal dicharges and run-off/ infiltration		Minor	Possible	Moderate (C2)
Dinoseb	0.007	mg/L			Chronic Health	Illegal dicharges and run-off/ infiltration		Minor	Possible	Moderate (C2)
Diquat	0.02	mg/L			Chronic Health	Illegal dicharges and run-off/ infiltration		Moderate	Possible	High (C3)
Endothall	0.1	mg/L			Chronic Health	Illegal dicharges and run-off/ infiltration		Minor	Possible	Moderate (C2)
Endrin	0.002	mg/L	0	0	Chronic Health	Illegal dicharges and run-off/ infiltration		Minor	Possible	Moderate (C2)
Epichlorohydrin	TT	mg/L			Chronic Health	Illegal dicharges and run-off/ infiltration		Moderate	Possible	High (C3)
Ethylene Dibromide	0.00005	mg/L			Chronic Health	Trade waste and run-off		Minor	Possible	Moderate (C2)
Glyphosate	0.7	mg/L			Chronic Health	Illegal dicharges and run-off/ infiltration		Minor	Possible	Moderate (C2)
Heptachlor	0.0004	mg/L	0	0	Chronic Health	Illegal dicharges and run-off/ infiltration		Moderate	Possible	High (C3)
Heptachlor Epoxide	0.0002	mg/L			Chronic Health	Illegal dicharges and run-off/ infiltration		Moderate	Possible	High (C3)
Hexachlorobenzene	0.001	mg/L	0	0	Chronic Health	Illegal dicharges and run-off/ infiltration		Moderate	Possible	High (C3)
Hexachlorocyclopentadiene	0.05	mg/L	0	0	Chronic Health	Illegal dicharges and run-off/ infiltration		Minor	Possible	Moderate (C2)

Hazard	Target (lower of EPA & VDH)	Unit	Ratio Max/Target Influent	Ratio Max/Target Effluent	Impact	Source	Notes	Inherent Risk (based on drinking untreated NP influent directly at 2 liters per day)		
								Consequence at Raw Water Concentration	Likelihood	Risk
Lindane	0.0002	mg/L	0	0	Chronic Health	Illegal dicharges and run-off/ infiltration		Moderate	Possible	High (C3)
Methoxychlor	0.04	mg/L	0	0	Chronic Health	Illegal dicharges and run-off/ infiltration		Minor	Possible	Moderate (C2)
Oxamyl	0.2	mg/L			Chronic Health	Illegal dicharges and run-off/ infiltration		Minor	Possible	Moderate (C2)
Pentachlorophenol	0.001	mg/L	0	0	Chronic Health	Illegal dicharges and run-off/ infiltration		Minor	Possible	Moderate (C2)
Picloram	0.5	mg/L			Chronic Health	Illegal dicharges and run-off/ infiltration		Minor	Possible	Moderate (C2)
Perfluorocarbons								Minor	Possible	Moderate (C2)
Polychlorinated Biphenyls	0.0005	mg/L	0	0	Chronic Health	Trade waste, Domestic waste, Illegal discharge		Moderate	Possible	High (C3)
Simazine	0.004	mg/L			Chronic Health	Illegal dicharges and run-off/ infiltration		Moderate	Possible	High (C3)
Styrene	0.1	mg/L						Moderate	Possible	High (C3)
Toxaphene	0.003	mg/L	0	0	Chronic Health	Illegal dicharges and run-off/ infiltration		Moderate	Possible	High (C3)
2,3,7,8-TCDD (Dioxin)	3E-08	mg/L			Chronic Health	Trade waste, Domestic waste, Illegal discharge, run-off		Minor	Possible	Moderate (C2)
2,4,5-TP (Silvex)	0.05	mg/L	0	0	Chronic Health	Illegal dicharges and run-off/ infiltration		Minor	Possible	Moderate (C2)

Hazard	Target (lower of EPA & VDH)	Unit	Ratio Max/Target Influent	Ratio Max/Target Effluent	Impact	Source	Notes	Inherent Risk (based on drinking untreated NP influent directly at 2 liters per day)		
								Consequence at Raw Water Concentration	Likelihood	Risk
DBPs and Disinfectants										
Bromate	0.01	mg/L			Chronic Health	Precursors in trade and domestic waste - Byproduct chlor(am)ination	From Ozone	Minor	Possible	Moderate (C2)
Chlorate	210	µg/L			Chronic Health	From hypochlorite	EPA HRL = 210 µg/L; Regulation at 800??	Minor	Likely	Moderate (D2)
Haloacetic acids (five) Precursors		mg/L				Organic Matter		Moderate	Almost Certain	High(E3)
Haloacetic acids (five)	0.06	mg/L			Chronic Health	Precursors in trade and domestic waste - Byproduct chlor(am)ination		Moderate	Almost Certain	High(E3)
NDMA Precursors		ng/L				Organic Matter		Moderate	Almost Certain	High(E3)
NDMA	10	ng/L			Chronic Health		Not regulated; CA Notification = 10 ng/L	Moderate	Almost Certain	High(E3)
Perchlorate	25	µg/L			Chronic Health	From Hypochlorite		Minor	Possible	Moderate (C2)
Total Trihalomethanes Precursors		mg/L				Organic Matter		Moderate	Almost Certain	High(E3)
Total Trihalomethanes	0.08	mg/L			Chronic Health	Precursors in trade and domestic waste - Byproduct chlor(am)ination		Moderate	Almost Certain	High(E3)

Notes:

µg/L= microgram(s) per liter
CA = California
EPA = U.S. Environmental Protection Agency
HRL = Health Reference Level
mg/L = milligram(s) per liter
NDMA = n-nitrosodimethylamine
ng/L = nanogram(s) per liter
NP = Nansemond Treatment Plant
pCi/L = picocurie(s) per liter
TT = Treatment Technique
VDH = Virginia Department of Health

Appendix B: Industrial Chemicals Matrix (empty cells indicate no available data)

Chemical Name	Industry Name	Annual Usage		
2,2 Azobis 2-ME Butyronitrile	BASF			
200 Solvent Oil	BASF			
2696-Intermediate	BASF			
2-Ethylhexyl Acrylate	BASF			
30W oil	Sentra Obici Hospital			
3M SS Cleaner and Polish	JMS Foodservice	10.0	each	/yr
6022947v1, br sgr, prok bacon, ssg, 42.36#	Smithfield Farmland			
6023048v1, smfd ssgseas with seasalt, 24 lb/bag	Smithfield Farmland			
A-1 Bleach	Wanchese Fish Company	468.0	gal	/yr
Acetic Acid	BASF			
Acetone	Sentra Obici Hospital			
Acetone	BASF	8,030.0	lbs	/yr
Acetone	BASF			
Acetone	Astro Pak Corportation			
Acids	SPSA Regional Landfill			
Acifoam VF10	JMS Foodservice	60.0	gal	/yr
Acrylamide	BASF	9,125.0	lbs	/yr
Acrylamide	BASF			
Acrylic Acid	BASF			
Acrylonitrile	BASF			
Acticide LG	BASF			
Activated Carbon Low Activity	BASF			
Adipic Acid	BASF			
AF-1334	Smithfield Farmland	803,000.0	lbs	/yr
AF-4960	Smithfield Farmland	915,420.0	lbs	/yr
AFFF	U.S. Coast Guard Base Portsmouth			
Ageflex FA1Q80MC	BASF			
Ageflex FM1Q80MC	BASF			
Ageflex MDADMAC	BASF			
Air Compressor Condensate	Sentra Obici Hospital			
Alcohol stains - isopropyl	Sentra Obici Hospital			
Alcoholic eosin y	Sentra Obici Hospital			
Alcohols	Sentra Obici Hospital			
Alcomer 120L	BASF			

Chemical Name	Industry Name	Annual Usage		
Alcomer 274	BASF			
Alcomer 783	BASF			
Alcotac CB9/ Glascol E7	BASF			
Alfonic 1412-7 Ethoxylate	BASF			
Allyl Chloride	U.S. Amines	13,140,000.0	lbs	/yr
Alpet D2	JMS Foodservice	10.0	gal	/yr
Alpet E3 Handsoap	Smithfield Farmland	15.6	gal	/yr
Altracut 159C	Flowserve			
Alum	G. Robert House, Jr. WTF			
Ammonia	U.S. Amines	1,971,000.0	lbs	/yr
Ammonia	Wanchese Fish Company			
Ammonia	G. Robert House, Jr. WTF			
Ammonium Bifluoride	Astro Pak Corportation			
Ammonium Hydroxide	BASF	11,680.0	lbs	/yr
Ammonium Hydroxide	BASF			
Ammonium Hydroxide	Astro Pak Corportation	36.5	?	/yr
Ammonium Persulfate	BASF			
AMPS 2403 Monomer	BASF			
Anionic Surfactant	Kraft Heinz Foods	200.0	lbs	/yr
Anti-freeze	VA Int Gateway			
Anti-freeze	Waste Management of Virginia			
Anti-freeze	Waste Industries			
Anti-freeze	U.S. Coast Guard Base Portsmouth			
Anti-freeze	Flowserve			
Anti-freeze	WB Diesel			
Aquaria Floor Finish	JMS Foodservice	10.0	gal	/yr
Ascorbic Acid	Smithfield Farmland			
ATF	Waste Management of Virginia			
ATF	Wanchese Fish Company			
Auto analyzer reagents	Sentra Obici Hospital			
Automatic transmission fluid	VA Int Gateway			
Avesta Red One 240 (pickling spray including hydrofluoric and nitric acid)	Astro Pak Corportation			
Bag Salt, top flo	Smithfield Farmland			
BasoNT 1030	BASF			
Beet sugar, 50# bag	Smithfield Farmland			
Benefit VC62	JMS Foodservice	4,000.0	gal	/yr
Biotec 077	BASF	182.5	lbs	/yr
Birk Trolley oil	Smithfield Farmland			
Birsh Knock-out Floor Cleaner	WB Diesel			

Chemical Name	Industry Name	Annual Usage		
Bleack KC 615	Smithfield Farmland			
Blue Gold	Astro Pak Corportation	273.8	?	/yr
Bluing reagent	Sentra Obici Hospital			
Boxglue	Supply One			
Brake fluid	VA Int Gateway			
Brine	G. Robert House, Jr. WTF			
Brown Sugar	Smithfield Farmland			
Brulin 815GD	Astro Pak Corportation	182.5	?	/yr
Brute4s trolley cleaner	Smithfield Farmland			
Butyl Acrylate	BASF			
Calclean Special HD 4143	JMS Foodservice	3.0	gal	/yr
Carefree low odor floor finish	Sentra Obici Hospital			
Carefree matte low-gloss floor finish	Sentra Obici Hospital			
Cationic Activator	BASF			
Caustic Solution (neutralized)	S. Church St. WTF	6,000.0	gal	/yr
CD 710	Smithfield Farmland			
Cerfa Kleen 5379	Flowserve			
Charsol h3	Smithfield Farmland			
Chec-mark Coolacide	U.S. Coast Guard Base Portsmouth	60.0	gal	/yr
CHEL DTPA-50 (Trilon C)	BASF			
Chemsearch 585	U.S. Coast Guard Base Portsmouth	240.0	gal	/yr
Chemsearch 8000 BD	U.S. Coast Guard Base Portsmouth	120.0	gal	/yr
Chemsearch 999	U.S. Coast Guard Base Portsmouth	180.0	gal	/yr
Chemsearch MB-1000, C/M	U.S. Coast Guard Base Portsmouth	12.0	gal	/yr
Chemstation 21991	Wanchese Fish Company	2,160.0	gal	/yr
Chemstation 5095 Potassium Hydroxide)	Electric Motor & Contracting Company	600.0	gal	/yr
Chemstation XP1001-86	Electric Motor & Contracting Company			
Chemtreat BL-1295	JMS Foodservice	440.0	gal	/yr
Chemtreat Boilercare BL 1295	Wanchese Fish Company	100.0	gal	/yr
Chemtreat Boilercare BL 8760	Wanchese Fish Company	30.0	gal	/yr
Chemtreat CL-1488	Wanchese Fish Company	100.0	gal	/yr
Chemtreat CL-1488	JMS Foodservice	550.0	gal	/yr
Chemtreat CL-2150	Wanchese Fish Company	15.0	gal	/yr
Chemtreat CL-2150	JMS Foodservice	60.0	gal	/yr
Chemtreat CL-216	Wanchese Fish Company	15.0	gal	/yr
Chemtreat CL-49	JMS Foodservice	60.0	gal	/yr
Chlorine tablets	Electric Motor & Contracting Company			
Chloroform	Kraft Heinz Foods			
Chromic Acid	Sentra Obici Hospital			
Cidex OPA (contains gluteraldehyde)	Sentra Obici Hospital			

Chemical Name	Industry Name	Annual Usage		
Cirrasol G-1086	BASF			
Citric Acid	Smithfield Farmland			
Citric Acid	Astro Pak Corportation	1,971.0	?	/yr
Clearedge 6519	Flowserve	1,320.0	gal	/yr
CLR Calcium Lime and Rust Remover	JMS Foodservice	5.0	gal	/yr
CNG	Waste Industries			
Coagulant (Nalco GR-305)	Kraft Heinz Foods	17,900.0	lbs	/yr
Coastal Power Bleast & Evolution Cleaner	VA Int Gateway			
Complex	JMS Foodservice	8,300.0	gal	/yr
Compressed Natural Gas	Waste Industries			
Compressor Oils	Flowserve			
Compressor Oils	Wanchese Fish Company			
Concrete floor patch	Wanchese Fish Company			
Concventional Pollutants	SPSA Regional Landfill			
Controlled pharmaceuticals	Sentra Obici Hospital			
Cool Cut (Machine coolent)	Electric Motor & Contracting Company			
Cooling Tower Treatment Chemical (Nalco)	Kraft Heinz Foods	5,400.0	lbs	/yr
Copper Nitrate	BASF			
Copper Sulfate	BASF			
Corn Syrup	Kraft Heinz Foods	292,000.0	gal	/yr
C-PAM	BASF			
Crew Neutral NA Non-acidic Bowl	JMS Foodservice	5.0	gal	/yr
Crew non-acid	Sentra Obici Hospital			
Crodafos T6A	BASF			
Crodamol OS	BASF			
Crystal Clean parts washing solvent	Waste Management of Virginia			
Ctng, ham, hmstyle	Smithfield Farmland			
Cure , pwdr, tec-cure	Smithfield Farmland			
Cure 15 pk/cs, 2.25#pk, 33.75#/cs	Smithfield Farmland			
Cytostain	Sentra Obici Hospital			
Dasco Kleen 12500	Flowserve			
Dasco Kleen 12517	Flowserve			
Dasco Kleen 12664	Flowserve			
Defoamer SS-1000	Smithfield Farmland	1,825.0	gal	/yr
Denatured Alcohol	BASF			
Deriphat 160C	BASF			
Dextrose	Smithfield Farmland			
Dextrose Monohydrate	BASF			
Dextrose, 50#	Smithfield Farmland			
Diallyl Phthalate	BASF			

Chemical Name	Industry Name	Annual Usage		
DIBAC	JMS Foodservice	900.0	gal	/yr
Diesel Exhaust Fluid	Waste Industries			
Diesel Fuel	Waste Management of Virginia			
Diesel Fuel	Waste Industries			
Diesel Fuel	SPSA Regional Landfill			
Diesel Fuel	Kraft Heinz Foods			
Diesel Fuel	VA Int Gateway			
Diesel Fuel	U.S. Coast Guard Base Portsmouth			
Diesel Fuel	Electric Motor & Contracting Company			
Diesel Fuel	Wanchese Fish Company			
Diesel Fuel	G. Robert House, Jr. WTF			
Diesel Fuel	WB Diesel			
Diesel Fuel	Chemres			
Diesel Fuel	BASF			
Diluted body fluids	Sentra Obici Hospital			
Dipropylene Glycol Methyl Ether	Kraft Heinz Foods	150.0	lbs	/yr
Disodium Phosphate	Astro Pak Corportation	299.3	?	/yr
Dispex AA 4040 NS	BASF			
Dispex CX 4225 NS	BASF			
Dispex CX 4240	BASF			
Dispex CX 4389	BASF			
Diton B	JMS Foodservice	5.0	gal	/yr
Diversay, stride hc neutral cleanerClorox Crème cleanser	Sentra Obici Hospital			
Diversay, suma breakup SC Heavy Duty foaming grease cleaner	Sentra Obici Hospital			
Divosan Spectrum	JMS Foodservice	300.0	gal	/yr
D-TROL	JMS Foodservice	20.0	gal	/yr
Dymon Liquid Alive	Wanchese Fish Company	5.0	gal	/yr
E2 Handsoap	Smithfield Farmland	1,040.0	gal	/yr
Electrowash PX	Electric Motor & Contracting Company			
Enamel Paint	Electric Motor & Contracting Company			
Enamel Paint	Wanchese Fish Company			
Endozime SLR	Sentra Obici Hospital			
Ensolve PL Antifoaming blend	Electric Motor & Contracting Company	60.0	gal	/yr
EP921	Flowserve			
Epoxy	Electric Motor & Contracting Company			
Epoxy Resin (EC1152-Dolf and Isopoxy 74041)	Electric Motor & Contracting Company			
Epoxy Thinner	U.S. Coast Guard Base Portsmouth			
Erythorbic Acid	Astro Pak Corportation	167.9	?	/yr
Ethanol	Sentra Obici Hospital			
Ethanol	BASF	3,285.0	lbs	/yr

Chemical Name	Industry Name	Annual Usage		
Ethanol	Kraft Heinz Foods			
Ethyl Acrylate	BASF			
Ethylene Dichloride	U.S. Amines	5,292,500.0	lbs	/yr
Ethylene Glycol	Wanchese Fish Company			
Ethylene Glycol	BASF			
Ethylene glycol monobutyl ether	Electric Motor & Contracting Company			
Evolution Cleaner by Meyer Labs	VA Int Gateway	108.0	gal	/yr
EZ 310 Enzyme cleaner	Smithfield Farmland			
FATSOLVE	JMS Foodservice	100.0	gal	/yr
Fatty Alcohol Ether Sulfate	BASF			
FC 607 Defoamer	BASF			
FCC Parts Cleaning Solvent	WB Diesel			
Floor Grip with Quat	Smithfield Farmland	20,800.0	lbs	/yr
Fluoride	S. Church St. WTF			
Foaming acid cleaner (liquid phosmoric cleaner)	Wanchese Fish Company	12.0	gal	/yr
Foaming Autoclave cleaning treatment system	Sentra Obici Hospital			
Formaldehyde	Sentra Obici Hospital			
Formic Acid	Astro Pak Corportation	91.3	?	/yr
Formula B12 steam cleaning detergent	Electric Motor & Contracting Company	180.0	gal	/yr
Freedom Floor Stripper	JMS Foodservice	5.0	gal	/yr
G946 (Sorbatan Monooleate)	BASF			
Gasoline	Sentra Obici Hospital			
Gasoline	SPSA Regional Landfill			
Gasoline	Kraft Heinz Foods			
Gasoline	VA Int Gateway			
Gasoline	U.S. Coast Guard Base Portsmouth			
Gasoline	Flowserve			
Gasoline	Electric Motor & Contracting Company			
Gasoline	Astro Pak Corportation			
Gasoline	Wanchese Fish Company			
Gelatin, type a, 300 bllom	Smithfield Farmland			
General housekeeping cleaners	S. Church St. WTF			
Glance glass multisurface cleaner	Sentra Obici Hospital			
Glaze, cntry ham	Smithfield Farmland			
Glutex II	Sentra Obici Hospital			
Glycinex	Sentra Obici Hospital			
Gojo E2 Foam Sanitizing Soap	JMS Foodservice	6.0	gal	/yr
Gojo Thick Pink Antiseptic Lotion	JMS Foodservice	30.0	gal	/yr
GP forward SC floor cleaner	Sentra Obici Hospital			
Gram stains	Sentra Obici Hospital			

Chemical Name	Industry Name	Annual Usage		
Grease	Waste Industries			
Grease	VA Int Gateway			
GS-5 Part	BASF			
HB2 Lacate Acid	Smithfield Farmland			
Heat exchanger fluid	Wanchese Fish Company			
Heavy metals	Kraft Heinz Foods			
Hematoxylin	Sentra Obici Hospital			
Hills 2942 CIA degreaser	Wanchese Fish Company			
Honey	Kraft Heinz Foods	292,000.0	gal	/yr
Hpcs-55, liquid smoke	Smithfield Farmland			
Hydraulic fluid	VA Int Gateway			
Hydraulic Oils	U.S. Coast Guard Base Portsmouth			
Hydraulic Oils	Waste Management of Virginia			
Hydraulic Oils	Waste Industries			
Hydraulic Oils	Wanchese Fish Company			
Hydraulic Oils	Supply One			
Hydraulic Oils	Flowserve			
Hydrochloric Acid	Sentra Obici Hospital			
Hydrochloric Acid	G. Robert House, Jr. WTF			
Hydrochloric Acid	QED			
Hydrochloric Acid	Astro Pak Corportation			
Hydrogen Peroxide	BASF			
Hydrogen Peroxide	Astro Pak Corportation	91.3	?	/yr
Hyprene L100	BASF			
Imbentin-N/350 G	BASF			
Ink Cleaner: ID-55 Ink Wash	Supply One	216.0	gal	/yr
Ink: J.M. Fry Low Copper Press Inks	Supply One	12.0	gal	/yr
Instant Hand Sanitizer	Smithfield Farmland	5.2	gal	/yr
Isopropanol	BASF	9,125.0	lbs	/yr
Isopropanol	Kraft Heinz Foods			
Isopropyl Alcohol	Astro Pak Corportation			
Isopropyl Alcohol	BASF			
Joncryl 652	BASF			
Jonrez A-2355 Presswash	Supply One			
Kathon LX Microbicide	BASF			
KC 365 Doorway foamer	Smithfield Farmland			
KC640 Glove sanitizer	Smithfield Farmland			
Klean Drain	JMS Foodservice	60.0	gal	/yr
Kleen MCT-103	QED	5,040.0	lbs	/yr
Kleen MCT-511	QED	5,040.0	lbs	/yr

Chemical Name	Industry Name	Annual Usage		
Koch kleen liquid detergent	Flowserve			
Krystol 70	BASF			
Lancer Acid	JMS Foodservice	15.0	gal	/yr
Lancer Clean	JMS Foodservice	15.0	gal	/yr
Latex/acrylic paint	Wanchese Fish Company			
Lime	S. Church St. WTF			
Liquichlor	Smithfield Farmland	4,992.0	gal	/yr
Liquid Nitrogen	BASF			
Lubricating Oils	U.S. Coast Guard Base Portsmouth			
Lubricating Oils	Waste Management of Virginia			
Lubricating Oils	Waste Industries			
Lubricating Oils	Supply One			
Lubricating Oils	Electric Motor & Contracting Company			
Lutensol TDA 8	BASF			
Magnafloc LT27	BASF			
Mare	Smithfield Farmland			
Mercuric Acetate	Sentra Obici Hospital			
Metal Medic 7345	Flowserve	240.0	gal	/yr
Methacrylic Acid	BASF			
Methallyl Chloride	U.S. Amines	14,191,200.0	lbs	/yr
Methanol	Sentra Obici Hospital			
Methanol	BASF	29,200.0	lbs	/yr
Methanol	Kraft Heinz Foods			
Methanol	BASF			
Methoxy Hydroquinone	BASF			
Methyl ethyl ketone	Kraft Heinz Foods			
Methylene Bis Acrylamide	BASF			
Mineral spirits	Astro Pak Corportation			
Minncare Cold Sterilant	QED	48.0	gal	/yr
Molasses	Smithfield Farmland			
Mono-ethylamine	U.S. Amines	6,278,000.0	lbs	/yr
Monopotassium Phosphate	BASF			
Motor Oil	VA Int Gateway			
Motor Oil	WB Diesel			
MP2C	Smithfield Farmland			
NABC Urinal Screens	JMS Foodservice	50.0	each	/yr
Nalco 2895 Plus	Sentra Obici Hospital	108.0	gal	/yr
Nalco 3DTrasar 3DT260	Sentra Obici Hospital	240.0	gal	/yr
Nalco 7469	Sentra Obici Hospital	5.3	lbs	/yr
Nalco 900005	Sentra Obici Hospital	45.0	gal	/yr

Chemical Name	Industry Name	Annual Usage		
Nalco NEXGUARD 22310	Sentra Obici Hospital	108.0	gal	/yr
Nalco Stabrex ST70	Sentra Obici Hospital	72.0	gal	/yr
Nalco Towerbrom 960	Sentra Obici Hospital	24.0	lbs	/yr
Nalco TRI-ADT 1820	Sentra Obici Hospital	54.0	gal	/yr
Napthol Solvent	BASF			
new paint	U.S. Coast Guard Base Portsmouth			
Nitric Acid	BASF			
Nitric Acid	Astro Pak Corportation			
Nitric Acid	Astro Pak Corportation	91.3	?	/yr
Nitric Acid	G. Robert House, Jr. WTF			
N-Methylpyrollidone	BASF			
No.2 heating fuel	Sentra Obici Hospital			
No.2 heating fuel	U.S. Coast Guard Base Portsmouth			
Non nut ingredients	Kraft Heinz Foods	13,760,500.0	lbs	/yr
Non-controlled pharmaceuticals	Sentra Obici Hospital			
Nonionic Surfactant	Kraft Heinz Foods	310.0	lbs	/yr
N-propyl bromide	Astro Pak Corportation			
Nuosept 95	BASF			
OIL 100S	BASF			
Oil based paints	Flowserve			
Organic Acids	Sentra Obici Hospital			
Paint Thinners	Electric Motor & Contracting Company			
Paint Thinners	Astro Pak Corportation			
Parol 85 HP	BASF			
Parts cleaning solvent	VA Int Gateway			
Parts cleaning solvent (naptha/citrus)	Kraft Heinz Foods			
PC 1210 Defoamer	Smithfield Farmland			
Peanut oil	Kraft Heinz Foods			
Peanut oil	Kraft Heinz Foods	7,519,000.0	gal	/yr
Peanuts	Kraft Heinz Foods	67,926,500.0	lbs	/yr
PEG 6000/K-PEG 6000	BASF			
Pepr, blk, 14-mesh	Smithfield Farmland			
Pepr, blk, 20-mesh	Smithfield Farmland			
Pepr, blk, 30x80-mesh	Smithfield Farmland			
Percol 3232L	BASF			
Phenothiazine	BASF			
Phosphate, instant, bk giulini	Smithfield Farmland			
Phosphate, stpp prayon carfosel	Smithfield Farmland			
Phosphoric Acid	Astro Pak Corportation	91.3	?	/yr
PIB Span	BASF			

Chemical Name	Industry Name	Annual Usage		
Pine Cleaner and Deodorizer	Smithfield Farmland	208.0	gal	/yr
Plastic blast media	Electric Motor & Contracting Company			
Plaza plus sealer/finish	Sentra Obici Hospital			
Polyflex CP.3	BASF			
Polymer	G. Robert House, Jr. WTF			
Polymer (Nalco GR-204)	Kraft Heinz Foods	2,800.0	lbs	/yr
Polytech 1407	Smithfield Farmland	13,140.0	lbs	/yr
Polytech 1407 (FeCl2)	Smithfield Farmland	255,500.0	gal	/yr
Polyurethane	Electric Motor & Contracting Company			
Potassium Bromate	BASF			
Potassium Carbonate	BASF			
Potassium Hydroxide	Astro Pak Corportation	273.8	?	/yr
Potassium, ace37%/l-lac18.5,ace p40	Smithfield Farmland			
Powdered Plastic Resin	Chemres			
Power steering fluid	Wanchese Fish Company			
Pro Chlor	Smithfield Farmland	10,166.0	gal	/yr
Pro CIP (chloroclean)	Smithfield Farmland	2,600.0	gal	/yr
Pro Phos	Smithfield Farmland	1,040.0	gal	/yr
Pro Plus	Smithfield Farmland	1,560.0	gal	/yr
Pro Solv	Smithfield Farmland	1,820.0	gal	/yr
ProChem Concrete Cleaner	WB Diesel	192.0	lbs	/yr
Pro-strip	Sentra Obici Hospital			
Protect 1650	Flowserve	1,200.0	gal	/yr
Ptroleum Based Oils	SPSA Regional Landfill			
Purasal hi pure	Smithfield Farmland			
Quaternary Ammonium	Wanchese Fish Company	192.0	gal	/yr
Quaternary Ammonium Chloride (Quat 256)	Kraft Heinz Foods			
Quintogen	Smithfield Farmland	936.0	gal	/yr
Rheovis AS 1130 NS	BASF			
Rheovis AS 1188	BASF			
Rheovis CDE	BASF			
Rheovis HS 1152	BASF			
Rheovis HS 1212	BASF			
Rheovis HS 1332	BASF			
Rhodococcus Rhodocrous	BASF			
RM 1849 Stabilizer	BASF			
RM 1849 Stabilizer	BASF			
RO Clean P111	QED	5,040.0	lbs	/yr
RO Clean P303	QED	5,040.0	lbs	/yr
Roto Extend	Flowserve			

Chemical Name	Industry Name	Annual Usage		
RPD-255	Smithfield Farmland	55.0	gal	/yr
Rtomadol 1-5 Oil	Astro Pak Corportation			
Salt	Smithfield Farmland			
Salt	Kraft Heinz Foods	912,500.0	lbs	/yr
Salt, morton, 80#	Smithfield Farmland			
Salt-yps-free (morton) 50# bag	Smithfield Farmland			
Santoquin	Smithfield Farmland	15,600.0	lbs	/yr
Sawdust, hardwood	Smithfield Farmland			
Scale Inhibitor VITEC 4000	S. Church St. WTF	84.0	gal	/yr
Scotchgard Tile and Grout Protector	JMS Foodservice	3.0	gal	/yr
Sealent roof patch	Wanchese Fish Company			
Seas, sage sausage	Smithfield Farmland			
Seas, saus p&b, 27# oz/bg	Smithfield Farmland			
Seas, saus, hot, jt	Smithfield Farmland			
Seas, saus, mild, jt	Smithfield Farmland			
Seasonning, ssg, golden corral, 24.75 lbs	Smithfield Farmland			
Silicone Defoamer Lambext E-2205	Univar			
Simple Green	U.S. Coast Guard Base Portsmouth			
Simple Green - All Purpose Cleaner	JMS Foodservice	105.0	gal	/yr
Smoke p-50	Smithfield Farmland			
Smoke, charsol, bulk, p-10	Smithfield Farmland			
Smoke, hkry, hlfbn	Smithfield Farmland			
Smoke, ra02-51	Smithfield Farmland			
Smoke, ra09027, bit, spray	Smithfield Farmland			
Smoked sugar liquid	Smithfield Farmland			
Smokehouse cleaner KC568	Smithfield Farmland			
Snapback UHS restorer	Sentra Obici Hospital			
Sodium Acrylate	BASF	13,505.0	lbs	/yr
Sodium Bisulfite	BASF			
Sodium Carbonate	Astro Pak Corportation	182.5	?	/yr
Sodium Carbonate	Wanchese Fish Company	2,000.0	gal	/yr
Sodium Carbonate	G. Robert House, Jr. WTF			
Sodium Citrate	Smithfield Farmland			
Sodium Eythorbate	Smithfield Farmland			
Sodium Gluconate	Astro Pak Corportation	299.3	?	/yr
Sodium Hydroxide	Sentra Obici Hospital			
Sodium Hydroxide	BASF	547,500.0	lbs	/yr
Sodium Hydroxide	BASF			
Sodium Hydroxide	BASF			
Sodium Hydroxide	Kraft Heinz Foods	44,900.0	lbs	/yr

Chemical Name	Industry Name	Annual Usage		
Sodium Hydroxide	U.S. Amines	7,701,500.0	gal	/yr
Sodium Hydroxide	Astro Pak Corportation	273.8	?	/yr
Sodium Hydroxide	G. Robert House, Jr. WTF			
Sodium Hydroxide	QED			
Sodium Hypochlorite	Smithfield Farmland	660.0	gal	/yr
Sodium Hypochlorite	Kraft Heinz Foods	1,800.0	lbs	/yr
Sodium Hypochlorite	S. Church St. WTF			
Sodium Hypochlorite	G. Robert House, Jr. WTF			
Sodium Hypophosphite	BASF			
Sodium Lauryl Ether Sulfate	BASF			
Sodium Metabisulfite	BASF			
Sodium Metabisulfite	QED	1,080.0	lbs	/yr
Sodium Nitrate	Smithfield Farmland			
Sodium Nitrite	Smithfield Farmland			
Sodium Nitrite	Astro Pak Corportation	36.5	?	/yr
Sodium tripolyphosphate, 50#	Smithfield Farmland			
Soidum Hydroxide	JMS Foodservice	25,000.0	gal	/yr
Solvents	SPSA Regional Landfill			
Solvents	U.S. Coast Guard Base Portsmouth			
Solvents	Flowserve			
Sorbitan Monooleate	BASF			
SPAN ™ 83-NV-LQ-(AP)	BASF			
Sparchlor	Wanchese Fish Company	120.0	gal	/yr
Spectak G VC Kosher	JMS Foodservice	12,000.0	gal	/yr
Spice, saus, ham	Smithfield Farmland			
Spitfire SC power cleaner	Sentra Obici Hospital			
Spring grove carpet cleaner	Sentra Obici Hospital			
SPS Sodium Persulfate	BASF			
SS 4 Quat	Smithfield Farmland	2,860.0	gal	/yr
Stearyl Methacrylate	BASF			
Sterocoll 802	BASF			
Sterrad NX Cassettes	Sentra Obici Hospital			
Stride Citrus HC	JMS Foodservice	10.0	gal	/yr
Sugar	Kraft Heinz Foods	2,080,500.0	lbs	/yr
Sugar, wht, cure, w/pepr	Smithfield Farmland			
Sugarcane	Smithfield Farmland			
Sulfuric Acid	BASF			
Sulfuric Acid	BASF	273,750.0	lbs	/yr
Sulfuric Acid	Kraft Heinz Foods	91,200.0	lbs	/yr
Sulfuric Acid	Astro Pak Corportation			

Chemical Name	Industry Name	Annual Usage		
Sulfuric Acid	JMS Foodservice	110.0	gal	/yr
Sulfuric Acid Solution (neutralized)	S. Church St. WTF	6,000.0	gal	/yr
Sulphur Dioxide	BASF			
Sumaclear (AlCl solution)	BASF			
Summerclear (35%AlCl)	BASF	365,000.0	lbs	/yr
Super nova .25NPHD detergent	Sentra Obici Hospital			
Super nova case dry	Sentra Obici Hospital			
Super nova instracreme lubricant	Sentra Obici Hospital			
Super nova multienzymatic cleaner .1, .25	Sentra Obici Hospital			
Surfonic P1	BASF			
Surgistain	Sentra Obici Hospital			
SWE 3308	BASF	511.0	lbs	/yr
SWE 3308	BASF			
SWE 5044	BASF	730.0	lbs	/yr
SWE 5044	BASF			
Syrup, corn solid, ds3150 drisweet42de, 50#	Smithfield Farmland			
T9 thinner	Flowserve			
Tannin Stain Remover	Sentra Obici Hospital			
TBPPI-75-AL1	BASF			
t-butylamine	U.S. Amines	6,205,000.0	lbs	/yr
T-Butylhydroperoxide	BASF			
Tech Cool 35052	Flowserve	2,640.0	gal	/yr
Telioform M300 US	BASF			
Telioform M305 US	BASF			
Telioform M305 US	BASF			
Tenox, 20-a	Smithfield Farmland			
Terditol 15S7 ST	BASF			
Tergitol TM 15-S-9	BASF			
Thioglycollic Acid	BASF			
Time Mist Time Wick Refill	JMS Foodservice	100.0	each	/yr
Tinuvin 400-DW	BASF			
Toilet bowl cleaner	Sentra Obici Hospital			
Toxic Organics	SPSA Regional Landfill			
Transmission Fluid	Waste Industries			
Transmission Fluid	WB Diesel			
Tree nuts	Kraft Heinz Foods	91,870,500.0	lbs	/yr
Tripolyphosphate	Wanchese Fish Company	8,000.0	gal	/yr
Trisodium Phosphate	Astro Pak Corportation	299.3	?	/yr
UHS floor cleaner	Sentra Obici Hospital			
Urea	Sentra Obici Hospital			

Chemical Name	Industry Name	Annual Usage		
Urea	BASF			
Used Oil	Waste Management of Virginia			
Used Oil	Wanchese Fish Company			
V. Mueller presoak instrument spray	Sentra Obici Hospital			
Vaden-100E Oil	Astro Pak Corportation			
Virex plus	Sentra Obici Hospital			
Waste oil	Kraft Heinz Foods			
Waste oil	U.S. Coast Guard Base Portsmouth			
Waste oil	Electric Motor & Contracting Company			
Waste oil	Wanchese Fish Company			
Waste paint	U.S. Coast Guard Base Portsmouth			
Water based paint	Waste Management of Virginia			
Water softener backflush	Sentra Obici Hospital			
Windex Powerized Glass Cleaner	JMS Foodservice	35.0	gal	/yr
Windshield washer fluid	VA Int Gateway			
Wood, Chips, apple	Smithfield Farmland			
Wood, Chips, hkry apple, 40# bag, 50bg/plt	Smithfield Farmland			
Wood, Chips, hkry, course, dry, 1/8 1/4	Smithfield Farmland			
Xanthan Gum	Kraft Heinz Foods	1,825.0	lbs	/yr
Xylene	Sentra Obici Hospital			
Xylene	Sentra Obici Hospital			
Xylene	Electric Motor & Contracting Company			
ZEP Concentrated Rinse Agent	Waste Management of Virginia			
ZEP Formula 22	Flowserve	120.0	gal	/yr
ZEP Formula 50	VA Int Gateway			
ZEP Formula 50	Electric Motor & Contracting Company	300.0	gal	/yr
ZEP Formula 50	Waste Management of Virginia	120.0	gal	/yr
ZEP Formula 940	VA Int Gateway			
ZEP parts cleaning solvent (Dayna143o)	Waste Industries			
ZEP Shopfloors	Waste Industries	12.0	gal	/yr
ZEP Truckwash	Waste Industries	420.0	gal	/yr
ZEP XT-1398 Automatic Truck Wash Detergent	Waste Management of Virginia			
Zetag 3930	BASF			
Zetag 4139	BASF			
Zetag 7523	BASF			
Zetag 7553	BASF			
Zetag 7557	BASF			
Zetag 7563	BASF			
Zetag 7583	BASF			
Zetag 7587	BASF			

Chemical Name	Industry Name	Annual Usage		
Zetag 7593	BASF			
Zetag 7652	BASF			
Zetag 7869	BASF			
Zetag 7878/7878FS40	BASF			
Zetag 7879/7879FS40	BASF			
Zetag 8115	BASF			
Zetag 8125	BASF			
Zetag 8127	BASF			
Zetag 8140	BASF			
Zetag 8147	BASF			
Zetag 8167	BASF			
Zetag 8187	BASF			
Zetag 8190	BASF			
Zetag 8812S	BASF			
Zetag 8814	BASF			
Zetag 8816	BASF	9,125.0	lbs	/yr
Zetag 8816	BASF			
Zetag 8818	BASF			
Zetag 8819	BASF			
Zetag 8828FSB	BASF			
Zetag 8844FS	BASF			
Zetag 8846FS	BASF			
Zetag 8847FSB	BASF			
Zetag 8848FS	BASF			
Zetag 8849FS	BASF			
Zetag 8857FSB	BASF			
Zetag 8858FSB	BASF			
Zetag 8868FS	BASF			
Zinc Orthophosphate	G. Robert House, Jr. WTF			
Z-Specialty Products: Formula 7007-5	WB Diesel	60.0	lbs	/yr
Z-Specialty Products: HA777-EZ	WB Diesel	60.0	lbs	/yr

Notes:
gal = gallon(s)
lbs = pound(s)